Microminerals from the Azores – the 2023 Harvest

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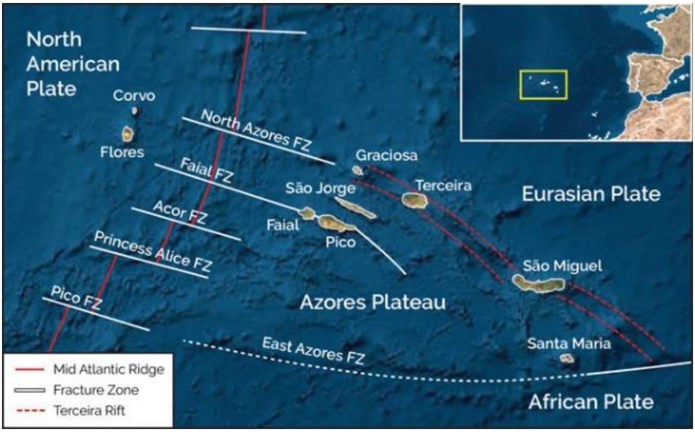
Henk wipes the sweat from his brow while he explores another mineral laden rock pile in exotic places from which he provides an insight into the microminerals of São Miguel in the Azores

In May 2023 three friends and I went on a mineral hunt for a week to São Miguel, the largest island in the Azores archipelago. The article below briefly discusses the geographical and geological aspects of the islands and the phenomenal landscapes that can be admired, before describing the most important mineral sites and revealing some of our finds.

The Archipelago One could rightly say that the term "in the middle of nowhere" applies here. The Azores are located in the Atlantic Ocean, with Portugal - to which the islands belong - as the nearest mainland at 1600 km to the east, and Newfoundland in North America at 2500 km to the west. To the north Greenland is 3900 km away, and to the south there is no mainland until Antarctica at 13500 km. The archipelago is part of the Mid-Atlantic Ridge, more or less at the intersection of three different continental plates: the North American Plate in the west and the Eurasian Plate in the east are the origin of the entire Mid-Atlantic Ridge, but here the African Plate in the southeast also comes into play.



Tectonics and the Azores (Source: Earthmagazine.org)

The complex interaction between the three continental plates is the cause of the unique location of the Azores. Their origin is estimated about 36 million years ago. Unlike the Hawaiian Islands, for example, there are no subduction zones here. The volcanic character of the islands arose purely from plate tectonics, which has created a complex set of fault zones and rifts.

The archipelago consists of nine islands, plus a large number of underwater volcanoes, in an area of about 450 km from east to west. The highest mountain in the archipelago, with its summit at 2351 meters, is located on the island of Pico, and is also the highest mountain in Portugal. The last volcanic eruption was in 1957, on the island of Faial but since then there has been no reason to fear new eruptions. To the east is the main island of São Miguel, and that is the island that I first visited in 2007 and returned to in 2023, and where all the mineral finds come from.

Lagoa do Fogo

São Miguel The main island, with the capital Ponta Delgada, is 60 km long and 10 to 15 km wide. It is dominated by the Agua de Pau volcano, which is virtually the geographical centre. In the middle of the volcano is the Lagoa do Fogo ("Fire Lake"). The two most important mineralogical hotspots are located on the flanks of Agua de Pau. There is a third interesting site, which mainly produces nice olivine crystals, called Mosteiros beach on the far west side of the island.

A lake in an ancient caldera

São Miguel's landscape is truly a feast for the eyes. Extremely green, with trees and tree ferns that are impressively tall, and with strong witnesses to the volcanic origin everywhere in the form of visible remains of ancient calderas.

The Mineral Collecting Sites The two main sites are located a short distance apart, on the northwest side of the volcano. The first is Vale das Lombadas, a natural occurrence in the shape of a fairly deep valley, part of the riverbed of the Ribeira Grande ("Great River"). The valley can be easily reached by car from the north via a narrow but paved mountain road. At the end of the road you can park near a group of dilapidated buildings that once served as a water bottling plant.

Luxuriant vegetation

The other site is an active quarry, called Pumice Quarry, which, in addition to pumice, is mainly quarried for basalt. The quarry can also be reached from the north. On both times that I have visited (in 2007 and in 2023), permission to search for minerals was given to us at the entrance .

The Pumice Quarry with a mineralogically interesting slope

A chunk of Syenite about 15 cm long

In both sites the base rock is not interesting, what we look for are xenoliths in the form of chunks of syenite. These are easy to spot as they are easily recognizable and abundant. And what's more - almost all of them contain desired microminerals. Syenite is a granitoid, with an alkali-feldspar/plagioclase ratio of 65 to 90% and less than 5% quartz. As the quartz content increases, syenite grades to granite. But while granite is extremely hard due to its high quartz content, syenite is relatively soft and brittle, due to the virtual absence of quartz. This has the advantage that there is a lot of room for free-standing crystals to form, but at the same time the disadvantage is that preserving the microminerals is certainly not an easy task. Fortunately, finding the syenites is very easy, the chunks can vary from a few centimetres to half a meter in size.

The current list in Mindat of minerals in the area of Agua de Pau contains 74 different species, four of which are type locality minerals. It is virtually impossible, no matter how rich the syenites are in micro minerals, to find them all, because many of them are extremely rare. The finds presented below are a selection of the mineral species found in our 2023 expedition, supplemented with a few that I obtained through exchange with other collectors.

The Challenges of Mineral Identification The dimensions of almost all minerals are less than a millimetre, meaning that correct identification requires a different approach than with larger pieces. Standard methods such as determining hardness, density or streak test are impossible. Therefore identification, in the absence of laboratory analysis requires a different knowledge and a different way of observing.

Aegirine FOV 0.5 mm
with crystal drawing (Source: Mineralienatlas.de)

Arfvedsonite 0,5 mm high
with crystal drawing (Source: Mineralienatlas.c

Identification depends on a precise description of the location, consideration of the possible paragenesis, careful observation of the colours and their nuances, and, above all, the close examination of the crystal shape and the visible end faces. Without these last two visual identification is completely impossible.

As an example, the comparison between two very similar minerals, aegirine and arfvedsonite, based on the crystal drawing facilitates the identification. Both specimens have the same colour, are both elongated, and at first glance look very similar. But the end faces are clearly different, so the crystal form provides clarity.

The Finds

Aegirine $NaFe^{3+}Si_2O_6$
Aegirine is one of the most common minerals at Agua de Pau. It belongs to the pyroxene group – or to be more precise - to the clinopyroxene subgroup. The bottle green colour is typical. It usually forms crystal groups, which are often quite jumbled, but almost always with well-developed crystals, which makes identification relatively easy.

Aegirine FOV 2 mm

Aenigmatite $Na_2Fe^{2+}{}_5TiSi_6O_{20}$
Agua de Pau produces several mineral species that are black in colour, and they often occur in close proximity to each other, and are therefore difficult to distinguish from

each other. The crystal shape and vertical striation of aenigmatite are characteristics of this mineral when the crystals are thick. Aenigmatite is an inosilicate (the silicate tetrahedron are linked in infinite chains). When it occurs as slimmer crystals they are usually grouped in sprays, and tend to be more towards reddish brown.

A thick crystal of aenigmatite FOV 2 mm

A spray of aenigmatite FOV 2 mm

Arfvedsonite $[Na][Na_2][Fe^{2+}{}_4Fe^{3+}]Si_8O_{22}(OH)_2$

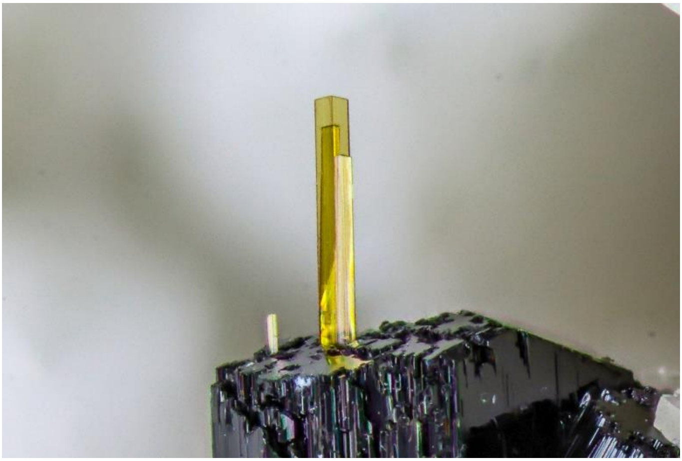
Arfvedsonite belongs to the amphibole supergroup. The crystal faces of arfvedsonite can range from simple (below left) to complex (below right), but are usually easy to observe and identify because of the well-developed crystals.

Arfvedsonite crystals 0.4 mm high

Arfvedsonite crystal 0.4 mm high

Astrophyllite $K_2NaFe^{2+}{}_7Ti_2Si_8O_{26}(OH)_4F$

Astrophyllite commonly occurs as extremely small crystals, but is nevertheless relatively easy to find due to its orange to orange-brown coloration which contrasts well with the usually white background. The crystals may look needle-shaped, but under high magnification they are always flat-shaped, occurring singly or in groups.



Astrophyllite, crystal 0.4 mm high, on a pedestal of amphibole

Fluornatropyrochlore $(Na,Pb,Ca,REE,U)_2Nb_2O_6F$

Without doubt the most abundant mineral in both Vale das Lombadas and the Pumice Quarry is fluornatropyrochlore. This niobium mineral can contain sodium, calcium, lead, uranium and/or Rare Earth Minerals. Literally every piece of matrix contains a number of these crystals. Usually loose, sometimes in groups of a few specimens, varying in colour from yellow to deep red, highly glossy, and almost always undamaged - they are truly a feast for the eyes. A second pyrochlore variety is also found, namely fluorcalciopyrochlore, but that is much rarer and usually unsightly.

Fluornatropyrochlore on amphibole, crystal 0.5 mm wide

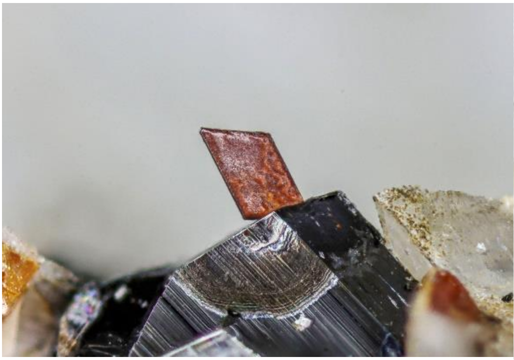
Fogoite-(Y) $Na_3Ca_2Y_2Ti(Si_2O_7)_2OF_3$

Fogoite-(Y), crystal 1 mm high

Fogoite-(Y) is one of the four type locality minerals, and is only known from Agua de Pau and takes its name from Lagoa de Fogo. Crystals of fogoite are rare but easy to recognise: they are creamy white to pale yellow, flat and lathlike in shape that can hardly be confused with anything else. So far they have only been found in Vale de Lombadas, and not (yet) in the pumice quarry. No other REE-variety is known.

Hematite and ilmenite - Fe_2O_3 and $Fe^{2+}TiO_3$

Ilmenite and hematite can look very similar, and normally they are not easy to tell apart. But although hematite also occurs here, ilmenite is much more present due to the abundant titanium. It is quite safe to regard the specimen below right as ilmenite – but with the caveat that it is a high probability rather than absolute certainty.



Hematite on amphibole, crystal 0,3 mm high

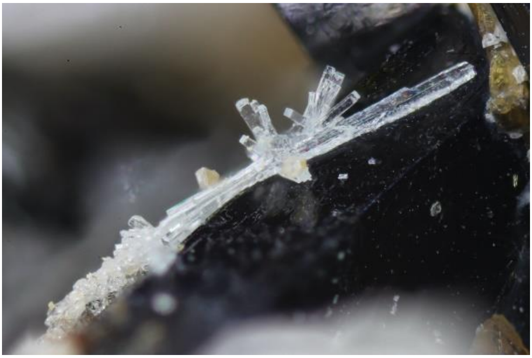
Ilmenite, crystal 0.4 mm wide

Sanidine $K(AlSi_3O_8)$

Although in most volcanic locations, for example the Eifel or the volcanoes of Tuscany, sanidine is very common and is often the matrix, good crystals are not easy to find in the Azores. Sanidine is the high-temperature, "fully disordered" form of K-feldspar – the other potassium-dominant feldspars are microcline (which is fully ordered) and orthoclase (partly ordered). It is metastable at room temperature and can revert to orthoclase over long geological periods. Sanidine is basically colourless but the crystal of sanidine in the photo below is iron stained.

Sanidine, crystal 4 mm high

Steacyite $Th(Ca,Na)_2K_{1-x}Si_8O_{20}$
To date, four different thorium minerals are known from the Azores, steacyite being one of them, along with thorite, turkestanite and huttonite – which are all very rare locally. The identification of steacyite is clear enough though: colourless tetragonal crystals, which can hardly be confused with anything else from Agua de Pau. The appearance in the photo is typical for the sites here.



Steacyite, FOV 0.4 mm

Titanite $CaTi(SiO_4)O$
Although titanium is an abundant component of the rock, titanite crystals are not as widespread as one might expect. Good crystals are not present in abundance. They occur in different habits, as titanite does everywhere. The colour varies from pale yellow to orange-brown, on a usually light background, which helps to spot and identify them.

Titanite crystal 0.5 mm high

Zircon $Zr(SiO_4)$

Zircon crystals are not very rare, are usually found in the company of pyrochlore and astrophyllite, but are not easy to discover. They are almost always white, and occasionally slightly yellowish - which makes the crystal below a very good find -, but given the mostly white matrix, finding them requires good detective work. The identification is usually relatively unambiguous: the crystals are almost always developed according to the textbook.

Zircon crystal 0.4 mm wide

Other minerals identified from this trip include one specimen from the bastnäsite group - $(Ce/Nd/Y/REE)(CO_3)F$. Without a formal analysis it is not possible to determine exactly which REE it contains. Another REE mineral identified was chevkinite-(Ce) - $Ce_4(Ti,Fe^{2+},Fe^{3+})_5O_8(Si_2O_7)_2$ - just as black as several other black minerals at Agua de Pau, but clearly recognizable by the crystal faces and characteristic very high lustre. As far as is known only the Ce-variety occurs here. Chiappinoite-(Y) has the formula - $Y_2Mn(Si_3O_7)_4$ - and is one of the four type locality minerals from Agua de Pau. It is extremely rare; so rare that worldwide it is only known from here. Although the crystal shape is actually unmistakable - see the drawing for illustration – it remains an educated guess whether the identification of this specimen based on visual observation is indeed entirely correct. Actually, it should

Chiappinoite-(Y) FOV 0.6 mm
with crystal drawing (Source: Mineralienatlas.de)

be formally analysed, but since this was the only find, sacrificing it for analysis would be too much to ask. Fergusonite-(Y) was another yttrium mineral found - $YNbO_4$ – which was found as orange to yellow elongated, double-terminated, spindle shaped crystals. Then only one conclusion is plausible: fergusonite-(Y). They also occur in some places in the Eifel, and those look exactly the same.

Rather less exotic but with a far more complex formula is ferro-katophorite - $\{Na\}\{CaNa\}\{Fe^{2+}{}_4Al\}[(AlSi_7)O_{22}](OH)_2$ - a member of the sodium-calcium amphibole subgroup, with Fe^{2+} dominant, hence the name ferro-katophorite. In all likelihood the vast majority of all amphiboles here are ferro-katophorite, but nevertheless good crystals are rather rare as most amphibole material occurs as irregularly shaped and distorted pieces. Molybdenite is a more familiar mineral which occurs in the same form as almost everywhere in the world: as thin, curved, irregular, highly glossy, metallic grey lamellae. And the last mineral that I want to mention is petarasite - $Na_5Zr_2(Si_6O_{18})(Cl,OH)\cdot 2H_2O$ which is one of the local rarities. We only found one specimen of it, and it has to be said that the crystal is not particularly beautiful or sharply defined. Nevertheless, there is no doubt about the identification: the colour, the opacity and the slightly rounded shape are characteristic - and yet again the "crystal drawing test" provides confirmation of the identification.

Acknowledgment The identification of the minerals in this article is based mainly on visual characteristics, and is entirely the responsibility of the author, with thanks for the support and advice of several colleagues. All photos are my own and can be found on my website www.tomeikminerals.com.

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Rock Chippings

Win some, lose some, Australian style

John Haupt reports that at the November West Coast Heritage & Minerals Fair at Zeehan in Western Tasmania, a recent find of yellow tinted brucite – $Mg(OH)_2$ - from the nearby Avebury Nickel Mine, generated a lot of interest with specimens being eagerly sought after. At the Avebury Mine company display stand at the show it was anticipated that the mine would restart producing nickel ore in the next few months, raising hopes that more brucite would be coming on to the market – along with substantial quantities of nickel. Alas! Shortly afterwards, a sharp drop in the nickel price resulted in the mine being returned to care and maintenance again. Shades of Hemerdon Bal / Drakelands Mine!